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Seasonal and weekly patterns of hospital admissions for acute diverticulitis

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Abstract. – OBJECTIVE: Onset and hospitalization of acute diseases do not occur randomly, but exhibit preferred high-risk temporal periods. The aim of this study, based on the database of hospital admissions of the Emilia-Romagna region of Italy, was to evaluate the possible existence of a seasonal or weekly pattern of hospitalization for acute diverticulitis (AD), and different rates of complications between weekend (WE) vs. weekday (WD) admissions.

PATIENTS AND METHODS: The study included all emergency hospital admissions in Emilia Romagna Region for AD between 1999 and 2011 (ICD-9-CM codes: 562.11-562.13). Day of admission was categorized, respectively, into four 3-month intervals, twelve 1-month intervals, seven 1-day intervals for statistical analysis, performed by c2 test goodness of fit and partial Fourier series on total number of cases, males and females, nonfatal or fatal cases, without and with hemorrhage.

RESULTS: The database contained records of 29,428 events of AD, relative to 24,843 different patients (mean age: 71.2±13.8 years; 40.5% males). Chronobiological analysis yielded a biphasic rhythmic pattern in AD admissions, characterized by two peaks in Autumn and Spring. As for day of admission, a progressive decrease of frequency during the week was observed. In turn, a slight increase of admissions on WE was observed for hemorrhagic events.

CONCLUSIONS: An excess burden of hospitalization for AD is observed in the region Emilia-Romagna of Italy, with demonstration of a biphasic cyclical pattern with peaks in Autumn and Spring. Again, a decreasing number of Monday to Friday admissions was observed. Further studies are needed to identify possible underlying causes.

Keywords:
Acute diverticulitis, Hospital admission, Emergency Department, Outcome, Seasons, Day-of-week, Chronobiology.

Background

A growing body of evidence indicated that onset and hospitalization of acute diseases do not occur randomly throughout seasons, months, or day-of-week, but exhibit peculiar preferred high-risk periods. On one hand, in fact, autumn and winter have shown highest peak of occurrence of acute myocardial infarction (AMI), ischemic cerebral accidents, acute aortic diseases, and pulmonary embolism[1-5]. On the other, Monday has been shown to be a critical day for onset of some acute diseases, too[6,7]. Several gastrointestinal diseases showed seasonal patterns of occurrence as well, e.g., inflammatory conditions, acute infective gastrointestinal diseases, upper gastrointestinal bleeding, peptic ulcer, acute pancreatitis, and appendicitis[8-14].

Diverticulosis is a common disease, affecting many patients, with frequent implications for emergency department (ED) physicians and surgeons. Its prevalence is estimated at 5% by the age of 40 years, up to 65% at 80 years of age[15]. The pathogenesis is complex, and probably multifactorial; however, the reason why only some subjects progress from asymptomatic to symptomatic, or even acute and complicated disease remains poorly understood. Recently, a study conducted on a large population in the United States[16] first reported the existence of a seasonal pattern in occurrence of acute diverticulitis (AD), characterized by a peak of highest frequency during summer months. The aim of the present study was to evaluate the possible existence of a seasonal and/or a weekly pattern of hospitalization for acute AD, in a large region of Italy, characterized by excellent health services, open 24/24 hours and 7/7 days, representative of our country as a whole. Moreover, due to recent worrisome evidence about increased risk of mortality of several cardiovascular diseases when hospitalization occurs on weekends (WE)[17-19], we analyzed the rates of complications between WE vs. weekday (WD).

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Patients and Methods

Emilia-Romagna is a region situated in north-eastern Italy, with a surface area of 22,124 Km^2, and a total population of ~4,300,000 people (≈7% of all Italy). Since 1978, Italy is provided with a National Health Service (NHS), based on the principle of 'universal entitlement', with the Government providing free and equal access to medical care to all residents. The NHS is largely under the control of regional governments and is administered by local health authorities (Azienda Sanitaria Locale/ASL).

Patient selection and eligibility

The analysis included all emergency hospital admissions for AD between January 1, 1999 and December 31, 2011, recorded in the database of the Region Emilia Romagna (RER) of Italy. In particular, only emergency admissions in which AD was indicated as the main discharge diagnosis were extracted from the database. Starting from 1999, the RER created an electronic database, tracking all discharge hospital sheets of patients admitted to hospitals. The discharge hospital sheet lists name and surname, gender, date of birth, date, hour and department of hospital admission/discharge, vital status at discharge, length-of-stay, primary and up to 15 secondary discharge diagnoses, and most important diagnostic procedures based on the International Classification of Diseases, ninth Revision, Clinical Modification (ICD-9-CM). To respect the privacy dispositions, RER health authorities removed patients' names from the database. A consecutive identification number for each patient was the only identification data allowed for analysis to categorize the admissions by age group and evaluation of rehospitalizations. We considered only emergency admission with primary or secondary diagnosis of:

- 562.11 Diverticulitis of colon without mention of hemorrhage
- 562.13 Diverticulitis of colon with hemorrhage

All recurrent admissions secondary to a primary event or a postoperative complication related to prior surgical management have been considered as one admission only.

Statistical Analysis

The total sample was divided into subgroups by gender, age (< 65, 65-74, ≥ 75 years), raw indicators of outcome, e.g., fatal (death during hospitalization) and nonfatal (patient discharged alive), and presence or not of hemorrhagic complications. To reduce the impact of age and co-morbidity as possible influencing factors in the analysis of in-hospital prognosis, we utilized the Charlson index modified for use with ICD-9-CM administrative databases, adjusted by age (CCIa)[20-22]. Based on day of admission (time of arrival to the ED), each case was categorized into:

- twelve 1-month intervals
- four 3-month intervals (Spring: March 21 to June 20, Summer: June 21 to September 20, Autumn: September 21 to December 20; Winter: December 21 to March 20)
- seven 1-day intervals, and occurrence of events on WE vs. WD. Admission on WE was defined as occurred from midnight of Friday to midnight of Sunday. The main national festive days in Italy (January 1, April 25, May 1, June 2, August 15, November 1, December 8, December 25 and 26) when occurring on WD, were considered as Sunday/WE.

The distribution of admissions was tested for uniformity in all groups by $\chi 2$ test goodness of fit[23]. Moreover, a further analysis on monthly and weekly admissions was performed to test the hypothesis of a cyclical variation, by applying partial Fourier series (Chronolab software)[24] to the time series data. This program selects the harmonic, or combination of harmonics, best explaining the temporal variance of the data. The percentage of the overall variance attributable to the approximated cosine function serves as the estimate of the goodness of fit, and the F-test statistic was used to test the zero-amplitude null hypothesis (absence of periodicity). The parameters calculated were: the midline estimated statistic of rhythm (MESOR, the rhythm-adjusted mean for the time period analyzed), amplitude (half the difference between the absolute maximum and minimum of the fitted approximation), and peak (acrophase) and trough (bathyphase).

Moreover, data of monthly admissions have been also adjusted for number of days, and the average number of admissions per month, according with Barnett & Dobson, Analysing Seasonal Health Data, Springer, 2010 (free download at: http://cran.r-project.org/web/packages/season/season.pdf).

Statistical analysis of demographic data was performed using SPSS 13.0 for Windows 2004 (SPSS Inc, Chicago, Ill). Significance levels were set at $p < 0.05$.

Results

During the observed period, the RER database contained records of 29,428 events of AD, relative to 24,843 different patients (mean age: 71.2±13.8 years), 10,074 males (40.5%; mean age: 67.3±15 years), and 14,769 females (59.5%; 74±12.3 years; $p < 0.001$). In 4,585 (15.5%) patients, a recurrent hospitalization was registered.

Conventional analysis

The monthly distribution of AD admissions for total population and different subgroups is shown in Figure 1. There was a biphasic pattern of highest frequency of admissions, with peaks in Spring and Autumn, with significant differences for subgroups by age, and for fatal events that showed a higher frequency in winter months (Table I).

As for seasonal distribution, the lowest frequency of admissions is shown in Winter (Figure 2), again with differences by age groups and fatal events (Table II).

As for day of admission, a progressive decrease of frequency during the week was observed (Table III, Figure 3). In turn, a modest (but statistically significant) increase of admissions on WE was observed for hemorrhagic events of AD (Table III, Figure 4).

Inferential analysis

Chronobiological analysis yielded a rhythmic pattern in AD admissions, characterized by a biphasic pattern with two peaks in Autumn and in Spring. In particular, a principal Autumn peak was found for total sample (12 Sept, $p = 0.031$, PR - percent of rhythm 74.2%), females (12 Sept, $p = 0.020$, PR 77.6%), subjects aged <65 years (15 Sep, $p = 0.030$, PR 74.5%), subjects aged 65-75 years (28 Sep, $p = 0.039$, PR 72.4%), non-fatal events (12 Sep, $p = 0.026$, PR 75.6%), fatal events (28 Nov, $p = 0.075$ NS, PR 66.1%), subjects without hemorrhage (10 Sep, $p = 0.026$, PR 75.5%), subjects with hemorrhage (18 Sep, $p = 0.141$ NS, PR 58.5%), whereas a principal Spring peak was found for Males (9 May, p =.506 NS, PR 31.2%)

Discussion

It has been shown that different emergencies exhibit precise circadian patterns of onset[25], and seasonal patterns of onset have been reported for several diseases as well[26-28].

To the best of our knowledge, the only available study aimed to evaluate the seasonal variation in onset of AD has been recently performed in the United States[16].

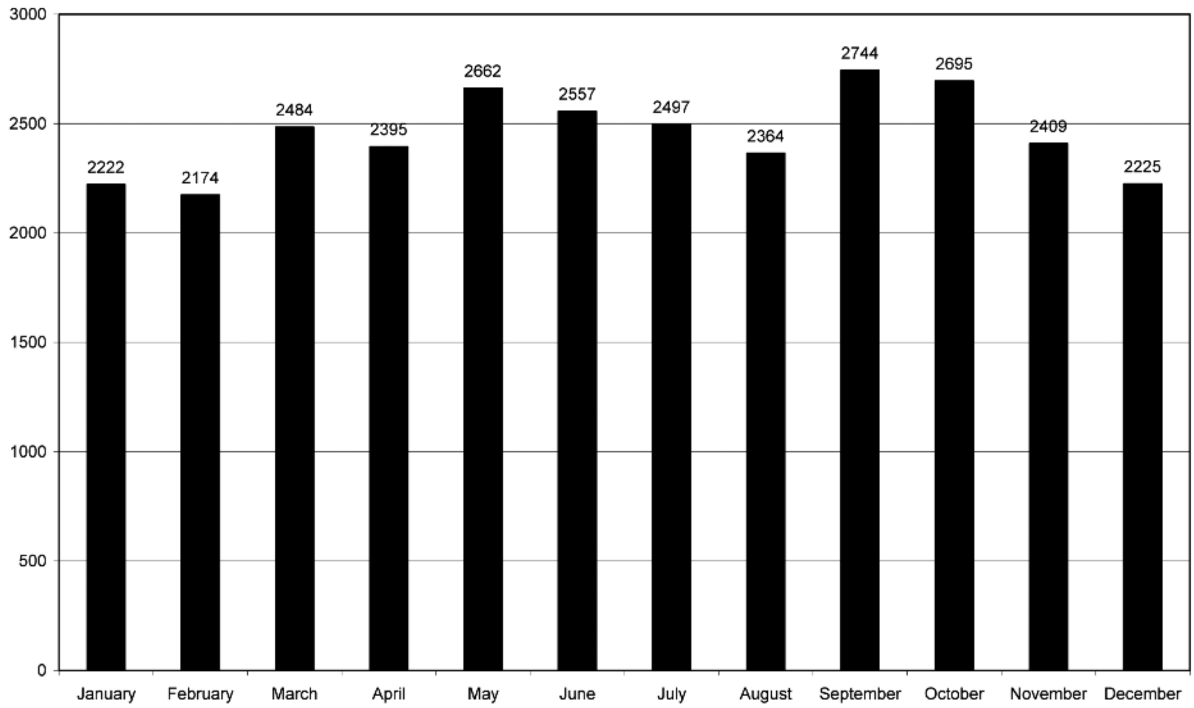

Figure 1. Monthly distribution of acute diverticulitis (AD) hospitalizations in the Emilia Romagna region of Italy (total population).

Table I. Circannual periodicity of hospital admission for acute diverticulitis (AD) for total sample and considered subgroups.

	Total		January		February		March		April		May		June		July		August		September		October		November		December		Within the group		Within groups	
																											Chi-square	p	Chi-square	p
Total sample	29428	100.0%	2222	7.6%	2174	7.4%	2484	8.4%	2395	8.1%	2662	9.0%	2557	8.7%	2497	8.5%	2364	8.0%	2744	9.3%	2695	9.2%	2409	8.2%	2225	7.6%	81.023	< 0.001		
Females	17613	59.9%	1340	7.6%	1266	7.2%	1490	8.5%	1447	8.2%	1624	9.2%	1522	8.6%	1475	8.4%	1458	8.3%	1628	9.2%	1591	9.0%	1434	8.1%	1338	7.6%	49.606	< 0.001	9.633	0.563
Males	11815	40.1%	882	7.5%	908	7.7%	994	8.4%	948	8.0%	1038	8.8%	1035	8.8%	1022	8.7%	906	7.7%	1116	9.4%	1104	9.3%	975	8.3%	887	7.5%	32.281	< 0.001		
< 65 yrs	8034	27.3%	576	7.2%	567	7.1%	677	8.4%	646	8.0%	767	9.5%	698	8.7%	659	8.2%	639	8.0%	802	10.0%	741	9.2%	683	8.5%	579	7.2%	42.216	< 0.001	37.675	0.020
65-75 yrs	7137	24.3%	522	7.3%	543	7.6%	588	8.2%	614	8.6%	613	8.6%	628	8.8%	610	8.5%	541	7.6%	628	8.8%	697	9.8%	622	8.7%	531	7.4%	24.558	< 0.001		
≥ 85 yrs	14257	48.4%	1124	7.9%	1064	7.5%	1219	8.6%	1135	8.0%	1282	9.0%	1231	8.6%	1228	8.6%	1184	8.3%	1314	9.2%	1257	8.8%	1104	7.7%	1115	7.8%	28.903	0.002		
Non fatal events	28831	98.0%	2166	7.5%	2128	7.4%	2434	8.4%	2364	8.2%	2614	9.1%	2511	8.7%	2445	8.5%	2314	8.0%	2693	9.3%	2645	9.2%	2349	8.1%	2168	7.5%	83.592	< 0.001	17.761	0.087
Fatal events	597	2.0%	56	9.4%	46	7.7%	50	8.4%	31	5.2%	48	8.0%	46	7.7%	52	8.7%	50	8.4%	51	8.5%	50	8.4%	60	10.1%	57	9.5%	6.579	0.859		
Without hemorrhage	24300	82.6%	1806	7.4%	1789	7.4%	2056	8.5%	1952	8.0%	2221	9.1%	2144	8.8%	2074	8.5%	1975	8.1%	2256	9.3%	2208	9.1%	1995	8.2%	1824	7.5%	73.449	< 0.001	12.569	0.322
With hemorrhage	5128	17.4%	416	8.1%	385	7.5%	428	8.3%	443	8.6%	441	8.6%	413	8.1%	423	8.2%	389	7.6%	488	9.5%	487	9.5%	414	8.1%	401	7.8%	13.880	0.240		

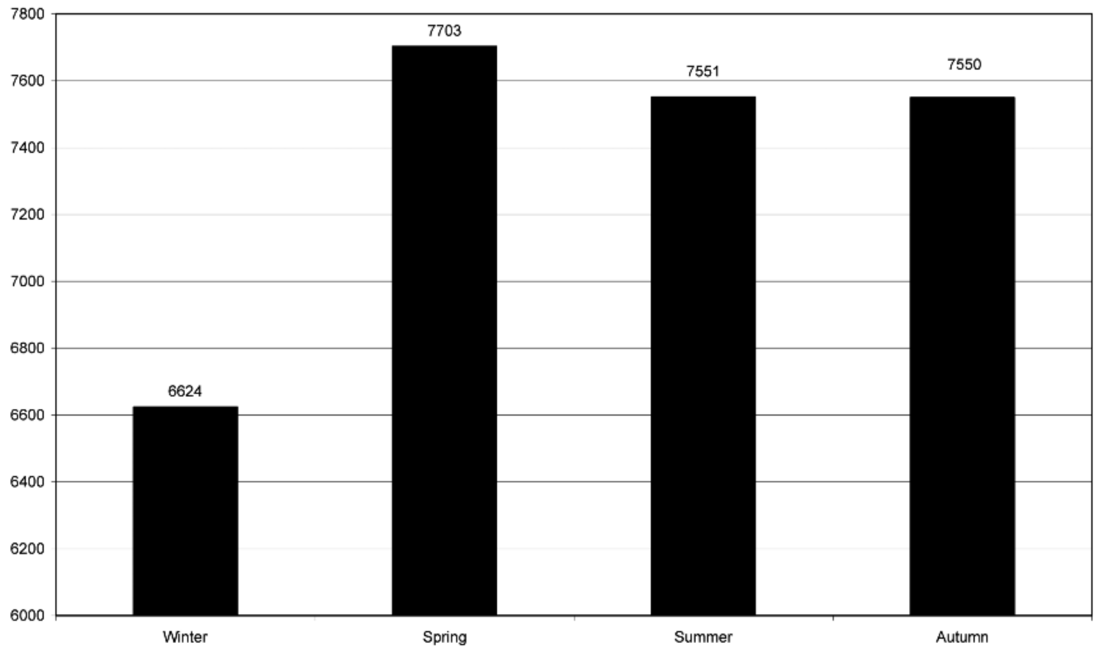

Figure 2. Seasonal distribution of acute diverticulitis (AD) hospitalizations in the Emilia Romagna region of Italy (total population).

Although in the presence of similar characteristics (database of administrative data, with no access to medical data, utilization of inferential sinusoidal analysis), and common relief that winter seems to be a low-frequency season, the two groups found different peaks. In fact, Ricciardi et al reported a main peak in Summer[16], and we here found two main peaks in Spring and Autumn. Nevertheless, given the great differences existing between United States and a region of Italy (climatic, dietary, social, of healthcare organization), it is somewhat difficult to draw conclusions regarding a disease with unknown cause.

Table II. Seasonal distribution of hospital admissions for acute diverticulitis (AD).

											Within the group		Within groups	
	Total		Winter		Spring		Summer		Autumn		Goodness of fit	*p*	Chi-square	*p*
Total sample	29428	100.0%	6624	22.5%	7703	26.2%	7551	25.7%	7550	25.7%	51.403	< 0.001		
Females	17613	59.9%	3928	22.3%	4673	26.5%	4511	25.6%	4501	25.6%	37.502	< 0.001	3.173	0.365
Males	11815	40.1%	2696	22.8%	3030	25.6%	3040	25.7%	3049	25.8%	25.128	< 0.001		
< 65 yrs	8034	27.3%	1732	21.6%	2124	26.4%	2085	26.0%	2093	26.1%	25.012	< 0.001	16.612	0.011
65-75 yrs	7137	24.3%	1586	22.2%	1862	26.1%	1776	24.9%	1913	26.8%	17.821	< 0.001		
≥ 85 yrs	14257	48.4%	3306	23.2%	3717	26.1%	3690	25.9%	3544	24.9%	15.149	0.002		
Non fatal events	28831	98.0%	6470	22.4%	7580	26.3%	7392	25.6%	7389	25.6%	53.736	< 0.001	10.788	0.011
Fatal events	597	2.0%	154	25.8%	123	20.6%	159	26.6%	161	27.0%	3.356	0.460		
Without hemorrhage	24300	82.6%	5423	22.3%	6348	26.1%	6307	26.0%	6222	25.6%	49.075	< 0.001	7.323	0.062
With hemorrhage	5128	17.4%	1201	23.4%	1355	26.4%	1244	24.3%	1328	25.9%	6.046	0.144		

Table III. Day-of-week distribution of hospital admissions for acute diverticulitis (AD).

																	Within the group		Within groups	
	Total		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Goodness of fit	*p*	Chi-square	*p*
Total sample	29428	100%	5403	18.4%	4587	15.6%	4475	15.2%	4437	15.1%	4053	13.8%	3398	11.5%	3075	10.4%	444.401	< 0.001		
Females	17613	59.9%	3183	18.1%	2709	15.4%	2749	15.6%	2684	15.2%	2441	13.9%	2061	11.7%	1786	10.1%	271.171	< 0.001	3.173	0.366
Males	11815	40.1%	2220	18.8%	1878	15.9%	1726	14.6%	1753	14.8%	1612	13.6%	1337	11.3%	1289	10.9%	180.151	< 0.001		
< 65 yrs	8034	27.3%	1564	19.5%	1277	15.9%	1202	15.0%	1213	15.1%	1057	13.2%	902	11.2%	819	10.2%	162.008	< 0.001	21.171	0.048
65-75 yrs	7137	24.3%	1301	18.2%	1111	15.6%	1039	14.6%	1075	15.1%	976	13.7%	849	11.9%	786	11.0%	86.459	< 0.001		
≥ 85 yrs	14257	48.4%	2538	17.8%	2199	15.4%	2234	15.7%	2149	15.1%	2020	14.2%	1647	11.6%	1470	10.3%	206.171	< 0.001		
Non fatal events	28831	98.0%	5295	18.4%	4495	15.6%	4395	15.2%	4342	15.1%	3968	13.8%	3320	11.5%	3016	10.5%	437.294	< 0.001	3.126	0.549
Fatal events	597	2.0%	108	18.1%	92	15.4%	80	13.4%	95	15.9%	85	14.2%	78	13.1%	59	9.9%	8.717	0.190		
Without hemorrhage	24300	82.6%	4521	18.6%	3806	15.7%	3685	15.2%	3678	15.1%	3339	13.7%	2806	11.5%	2465	10.1%	409.267	< 0.001	18.072	0.006
With hemorrhage	5128	17.4%	882	17.2%	781	15.2%	790	15.4%	759	14.8%	714	13.9%	592	11.5%	610	11.9%	44.344	< 0.001		

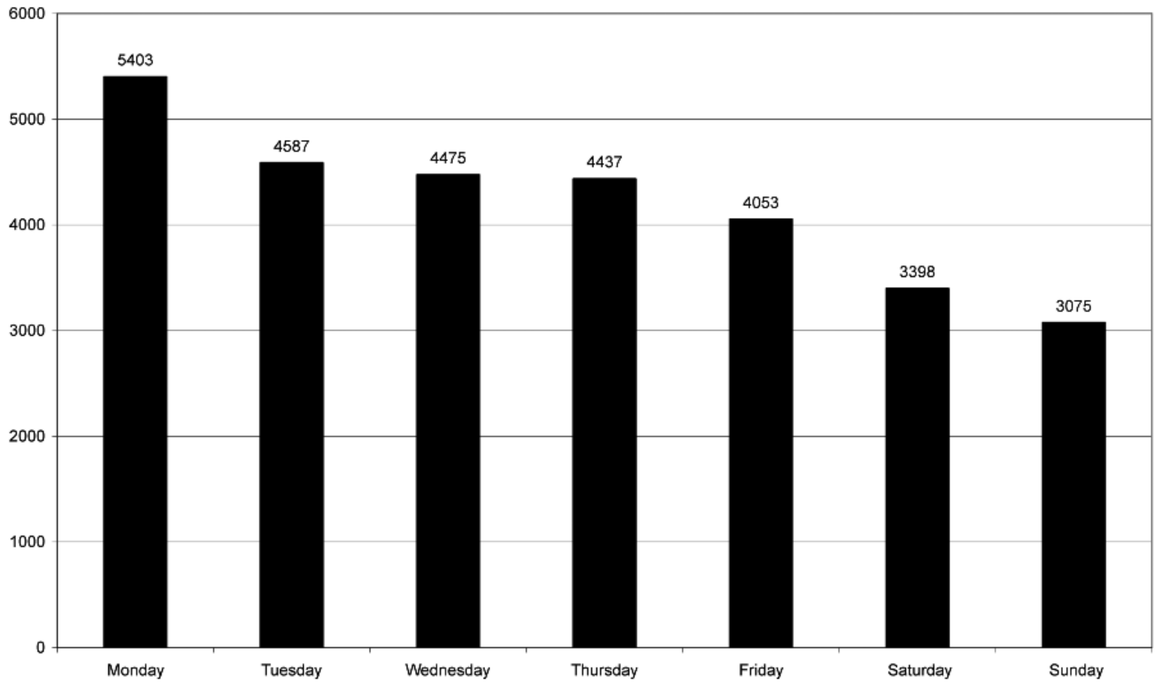

Figure 3. Day-of-week distribution of acute diverticulitis (AD) hospitalizations in the Emilia Romagna region of Italy (total population).

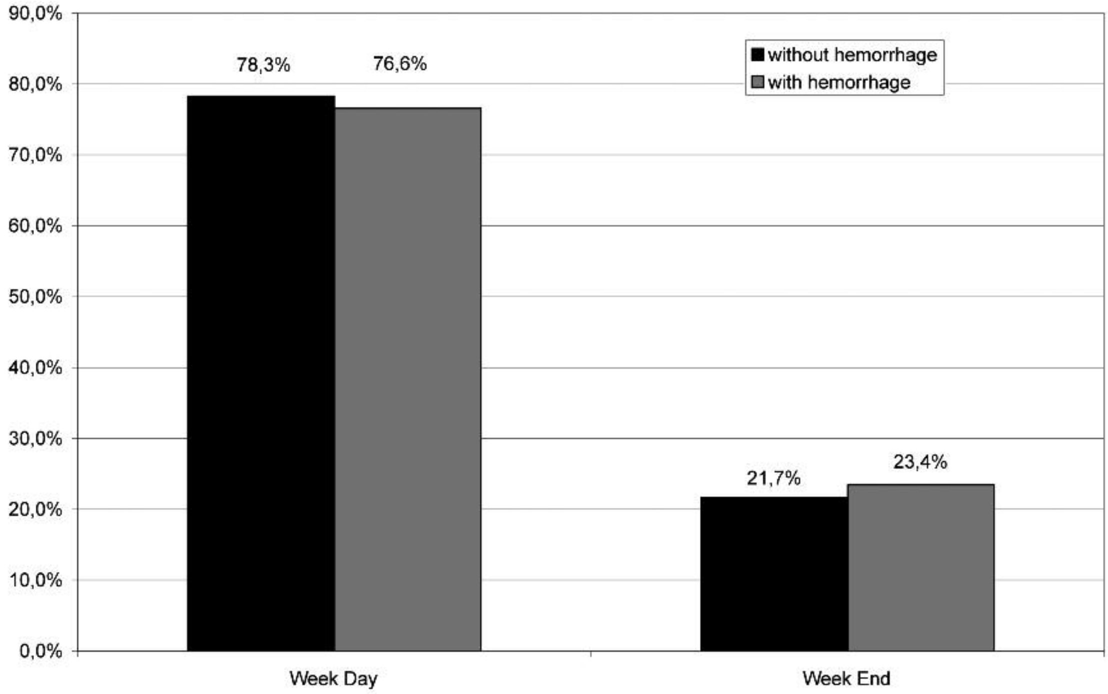

Figure 4. Weekday vs. weekend distribution of acute diverticulitis (AD): cases with or without hemorrhagic complication.

In fact, the pathogenesis of diverticular disease is probably multifactorial, involving dietary habits, changes in colonic pressure, motility and wall structure associated with ageing[29]. Also Ricciardi et al. stated that an obvious cause or trigger for AD cannot be given, but only hypothesis can be made[16]. They gave importance to the similar summer pattern of other inflammatory intestinal diseases, such as appendicitis[11,30-31], put forward the hypothesis that infectious causes may play a role[16].

We found that winter could represent a low-frequency but a high-risk season, since fatal cases showed a peak just in this season. We have previously observed a similar pattern, with increased risk of death in Autumn-Winter, for acute appendicitis[11] and acute pancreatitis[14]. It is possible that a correlation with infectious diseases and patients' comorbidities may exist.

On the other hand, given also the differences in the incidence of diverticular disease in different continents, a possible causative role by for processed foods and deficiency of insoluble fiber can be hypothesized[32,33], seasonal variation in alimentary habits could also be considered[34].

As for weekly distribution, the increase of admissions on the first days of the week is similar to that observed for other cardiovascular diseases, and it is probably in relation with the organization of medical service. In particular, in our National (and Regional) healthcare organization, general practitioners (GPs) operate from Monday to Friday and are not available during the WE. During holidays and WE, GPs are backed up by a dedicated staff of younger doctors on-call, who have less experience and are not provided of complete patients' informations. Thus, it is likely that acute situations with high emotional impact, e.g., acute abdominal pain, or bleeding, induce patients to seek help directly to the ED during WE.

This study has several limitations, common to retrospective studies based on administrative codification[35]. First, utilization of ICD 9-CM code may be biased by the physicians' habits with regard to assigning a diagnosis and possible consequences, e.g., errors of codification, underestimation, and missing code. Second, information on the severity of illness is not available. In fact, it is impossible to obtain data about duration of symptoms, appropriateness and timeliness of diagnoses, drugs taken at home, possible precipitating factors, which could perhaps explain the different outcomes among patients admitted on different times of years and week. Thus, we decided to limit ourselves to simple raw indicators of outcome, such as fatal (death during hospitalization) or nonfatal (discharge alive) cases, and considered only the primary cause of death or discharge diagnosis. Third, caution must be used in the interpretation of hospitalization data, that do not provide information on ambulatory outpatients, and miss any out-of-hospital information. Given these limitations, however, the study has also some strenghts, such as its size and long period of observation (13 years), and data well representative of the real-life management outcome of AD patients referring to an ED. Moreover, this is the first study on this topic in the European continent.

Conclusions

Also in a large region of Italy, an excess burden of AD hospitalizations is observed in Autumn and Spring. Again, a decreasing number of Monday to Friday admissions has been observed. Although it seems impossible to draw any explanation from this study, it is possible that either multifactorial agents, e.g., climatic changes, migration or vacation patterns, lifestyle, dietary habits, medication use may play a favoring role, and body's predisposition according with seasonal endogenous rhythms[36] may also concur. Prospective clinical studies are so needed to confirm these preliminary different observations, obtained in different Countries.

Heman Partecipant Protection

No protocol approval was needed for this study because no human participants were involved.

Competing of interest

The authors declare that they have no competing interests.

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